

SKADDEN, ARPS, SLATE, MEAGHER & FLOM  
FOUR TIMES SQUARE  
NEW YORK, NY 10036-6522

---

UNITED STATES PATENT APPLICATION

---

BE IT KNOWN THAT I, **STEPHEN J. DAVIS**, A CITIZEN OF THE UNITED  
STATES, RESIDING AT VIA DEI BORGHI 52, CAVASO DEL TOMBA,  
TREVISO, ITALY, HAVE INVENTED AN IMPROVEMENT IN

TWO PIECE SPORTS RACQUET AND METHOD

FOR WHICH THE FOLLOWING IS A SPECIFICATION.

## TITLE OF THE INVENTION

## Two Piece Sports Racquet And Method

5

## BACKGROUND OF THE INVENTION

The present invention relates to sports racquets such as tennis racquets, squash racquets, badminton racquets, and racquetball racquets, which have hollow tubular frames made of composite materials such as "graphite". High performance sports racquets have a hollow tubular wall made of graphite material. To make such racquets, an elongated tube of pre-preg, formed of uncured graphite, is placed in a mold in the desired shape of the racquet frame. A bladder placed inside the pre-preg tube is inflated, such that the pre-preg assumes the shape of the mold, and the mold is heated to cure the epoxy resin and harden the frame.

10  
15  
20  
25  
30  
35  
40  
45  
50  
55  
60  
65  
70  
75  
80  
85  
90  
95  
100  
105  
110  
115  
120  
125  
130  
135  
140  
145  
150  
155  
160  
165  
170  
175  
180  
185  
190  
195  
200  
205  
210  
215  
220  
225  
230  
235  
240  
245  
250  
255  
260  
265  
270  
275  
280  
285  
290  
295  
300  
305  
310  
315  
320  
325  
330  
335  
340  
345  
350  
355  
360  
365  
370  
375  
380  
385  
390  
395  
400  
405  
410  
415  
420  
425  
430  
435  
440  
445  
450  
455  
460  
465  
470  
475  
480  
485  
490  
495  
500  
505  
510  
515  
520  
525  
530  
535  
540  
545  
550  
555  
560  
565  
570  
575  
580  
585  
590  
595  
600  
605  
610  
615  
620  
625  
630  
635  
640  
645  
650  
655  
660  
665  
670  
675  
680  
685  
690  
695  
700  
705  
710  
715  
720  
725  
730  
735  
740  
745  
750  
755  
760  
765  
770  
775  
780  
785  
790  
795  
800  
805  
810  
815  
820  
825  
830  
835  
840  
845  
850  
855  
860  
865  
870  
875  
880  
885  
890  
895  
900  
905  
910  
915  
920  
925  
930  
935  
940  
945  
950  
955  
960  
965  
970  
975  
980  
985  
990  
995  
1000  
1005  
1010  
1015  
1020  
1025  
1030  
1035  
1040  
1045  
1050  
1055  
1060  
1065  
1070  
1075  
1080  
1085  
1090  
1095  
1100  
1105  
1110  
1115  
1120  
1125  
1130  
1135  
1140  
1145  
1150  
1155  
1160  
1165  
1170  
1175  
1180  
1185  
1190  
1195  
1200  
1205  
1210  
1215  
1220  
1225  
1230  
1235  
1240  
1245  
1250  
1255  
1260  
1265  
1270  
1275  
1280  
1285  
1290  
1295  
1300  
1305  
1310  
1315  
1320  
1325  
1330  
1335  
1340  
1345  
1350  
1355  
1360  
1365  
1370  
1375  
1380  
1385  
1390  
1395  
1400  
1405  
1410  
1415  
1420  
1425  
1430  
1435  
1440  
1445  
1450  
1455  
1460  
1465  
1470  
1475  
1480  
1485  
1490  
1495  
1500  
1505  
1510  
1515  
1520  
1525  
1530  
1535  
1540  
1545  
1550  
1555  
1560  
1565  
1570  
1575  
1580  
1585  
1590  
1595  
1600  
1605  
1610  
1615  
1620  
1625  
1630  
1635  
1640  
1645  
1650  
1655  
1660  
1665  
1670  
1675  
1680  
1685  
1690  
1695  
1700  
1705  
1710  
1715  
1720  
1725  
1730  
1735  
1740  
1745  
1750  
1755  
1760  
1765  
1770  
1775  
1780  
1785  
1790  
1795  
1800  
1805  
1810  
1815  
1820  
1825  
1830  
1835  
1840  
1845  
1850  
1855  
1860  
1865  
1870  
1875  
1880  
1885  
1890  
1895  
1900  
1905  
1910  
1915  
1920  
1925  
1930  
1935  
1940  
1945  
1950  
1955  
1960  
1965  
1970  
1975  
1980  
1985  
1990  
1995  
2000  
2005  
2010  
2015  
2020  
2025  
2030  
2035  
2040  
2045  
2050  
2055  
2060  
2065  
2070  
2075  
2080  
2085  
2090  
2095  
2100  
2105  
2110  
2115  
2120  
2125  
2130  
2135  
2140  
2145  
2150  
2155  
2160  
2165  
2170  
2175  
2180  
2185  
2190  
2195  
2200  
2205  
2210  
2215  
2220  
2225  
2230  
2235  
2240  
2245  
2250  
2255  
2260  
2265  
2270  
2275  
2280  
2285  
2290  
2295  
2300  
2305  
2310  
2315  
2320  
2325  
2330  
2335  
2340  
2345  
2350  
2355  
2360  
2365  
2370  
2375  
2380  
2385  
2390  
2395  
2400  
2405  
2410  
2415  
2420  
2425  
2430  
2435  
2440  
2445  
2450  
2455  
2460  
2465  
2470  
2475  
2480  
2485  
2490  
2495  
2500  
2505  
2510  
2515  
2520  
2525  
2530  
2535  
2540  
2545  
2550  
2555  
2560  
2565  
2570  
2575  
2580  
2585  
2590  
2595  
2600  
2605  
2610  
2615  
2620  
2625  
2630  
2635  
2640  
2645  
2650  
2655  
2660  
2665  
2670  
2675  
2680  
2685  
2690  
2695  
2700  
2705  
2710  
2715  
2720  
2725  
2730  
2735  
2740  
2745  
2750  
2755  
2760  
2765  
2770  
2775  
2780  
2785  
2790  
2795  
2800  
2805  
2810  
2815  
2820  
2825  
2830  
2835  
2840  
2845  
2850  
2855  
2860  
2865  
2870  
2875  
2880  
2885  
2890  
2895  
2900  
2905  
2910  
2915  
2920  
2925  
2930  
2935  
2940  
2945  
2950  
2955  
2960  
2965  
2970  
2975  
2980  
2985  
2990  
2995  
3000  
3005  
3010  
3015  
3020  
3025  
3030  
3035  
3040  
3045  
3050  
3055  
3060  
3065  
3070  
3075  
3080  
3085  
3090  
3095  
3100  
3105  
3110  
3115  
3120  
3125  
3130  
3135  
3140  
3145  
3150  
3155  
3160  
3165  
3170  
3175  
3180  
3185  
3190  
3195  
3200  
3205  
3210  
3215  
3220  
3225  
3230  
3235  
3240  
3245  
3250  
3255  
3260  
3265  
3270  
3275  
3280  
3285  
3290  
3295  
3300  
3305  
3310  
3315  
3320  
3325  
3330  
3335  
3340  
3345  
3350  
3355  
3360  
3365  
3370  
3375  
3380  
3385  
3390  
3395  
3400  
3405  
3410  
3415  
3420  
3425  
3430  
3435  
3440  
3445  
3450  
3455  
3460  
3465  
3470  
3475  
3480  
3485  
3490  
3495  
3500  
3505  
3510  
3515  
3520  
3525  
3530  
3535  
3540  
3545  
3550  
3555  
3560  
3565  
3570  
3575  
3580  
3585  
3590  
3595  
3600  
3605  
3610  
3615  
3620  
3625  
3630  
3635  
3640  
3645  
3650  
3655  
3660  
3665  
3670  
3675  
3680  
3685  
3690  
3695  
3700  
3705  
3710  
3715  
3720  
3725  
3730  
3735  
3740  
3745  
3750  
3755  
3760  
3765  
3770  
3775  
3780  
3785  
3790  
3795  
3800  
3805  
3810  
3815  
3820  
3825  
3830  
3835  
3840  
3845  
3850  
3855  
3860  
3865  
3870  
3875  
3880  
3885  
3890  
3895  
3900  
3905  
3910  
3915  
3920  
3925  
3930  
3935  
3940  
3945  
3950  
3955  
3960  
3965  
3970  
3975  
3980  
3985  
3990  
3995  
4000  
4005  
4010  
4015  
4020  
4025  
4030  
4035  
4040  
4045  
4050  
4055  
4060  
4065  
4070  
4075  
4080  
4085  
4090  
4095  
4100  
4105  
4110  
4115  
4120  
4125  
4130  
4135  
4140  
4145  
4150  
4155  
4160  
4165  
4170  
4175  
4180  
4185  
4190  
4195  
4200  
4205  
4210  
4215  
4220  
4225  
4230  
4235  
4240  
4245  
4250  
4255  
4260  
4265  
4270  
4275  
4280  
4285  
4290  
4295  
4300  
4305  
4310  
4315  
4320  
4325  
4330  
4335  
4340  
4345  
4350  
4355  
4360  
4365  
4370  
4375  
4380  
4385  
4390  
4395  
4400  
4405  
4410  
4415  
4420  
4425  
4430  
4435  
4440  
4445  
4450  
4455  
4460  
4465  
4470  
4475  
4480  
4485  
4490  
4495  
4500  
4505  
4510  
4515  
4520  
4525  
4530  
4535  
4540  
4545  
4550  
4555  
4560  
4565  
4570  
4575  
4580  
4585  
4590  
4595  
4600  
4605  
4610  
4615  
4620  
4625  
4630  
4635  
4640  
4645  
4650  
4655  
4660  
4665  
4670  
4675  
4680  
4685  
4690  
4695  
4700  
4705  
4710  
4715  
4720  
4725  
4730  
4735  
4740  
4745  
4750  
4755  
4760  
4765  
4770  
4775  
4780  
4785  
4790  
4795  
4800  
4805  
4810  
4815  
4820  
4825  
4830  
4835  
4840  
4845  
4850  
4855  
4860  
4865  
4870  
4875  
4880  
4885  
4890  
4895  
4900  
4905  
4910  
4915  
4920  
4925  
4930  
4935  
4940  
4945  
4950  
4955  
4960  
4965  
4970  
4975  
4980  
4985  
4990  
4995  
5000  
5005  
5010  
5015  
5020  
5025  
5030  
5035  
5040  
5045  
5050  
5055  
5060  
5065  
5070  
5075  
5080  
5085  
5090  
5095  
5100  
5105  
5110  
5115  
5120  
5125  
5130  
5135  
5140  
5145  
5150  
5155  
5160  
5165  
5170  
5175  
5180  
5185  
5190  
5195  
5200  
5205  
5210  
5215  
5220  
5225  
5230  
5235  
5240  
5245  
5250  
5255  
5260  
5265  
5270  
5275  
5280  
5285  
5290  
5295  
5300  
5305  
5310  
5315  
5320  
5325  
5330  
5335  
5340  
5345  
5350  
5355  
5360  
5365  
5370  
5375  
5380  
5385  
5390  
5395  
5400  
5405  
5410  
5415  
5420  
5425  
5430  
5435  
5440  
5445  
5450  
5455  
5460  
5465  
5470  
5475  
5480  
5485  
5490  
5495  
5500  
5505  
5510  
5515  
5520  
5525  
5530  
5535  
5540  
5545  
5550  
5555  
5560  
5565  
5570  
5575  
5580  
5585  
5590  
5595  
5600  
5605  
5610  
5615  
5620  
5625  
5630  
5635  
5640  
5645  
5650  
5655  
5660  
5665  
5670  
5675  
5680  
5685  
5690  
5695  
5700  
5705  
5710  
5715  
5720  
5725  
5730  
5735  
5740  
5745  
5750  
5755  
5760  
5765  
5770  
5775  
5780  
5785  
5790  
5795  
5800  
5805  
5810  
5815  
5820  
5825  
5830  
5835  
5840  
5845  
5850  
5855  
5860  
5865  
5870  
5875  
5880  
5885  
5890  
5895  
5900  
5905  
5910  
5915  
5920  
5925  
5930  
5935  
5940  
5945  
5950  
5955  
5960  
5965  
5970  
5975  
5980  
5985  
5990  
5995  
6000  
6005  
6010  
6015  
6020  
6025  
6030  
6035  
6040  
6045  
6050  
6055  
6060  
6065  
6070  
6075  
6080  
6085  
6090  
6095  
6100  
6105  
6110  
6115  
6120  
6125  
6130  
6135  
6140  
6145  
6150  
6155  
6160  
6165  
6170  
6175  
6180  
6185  
6190  
6195  
6200  
6205  
6210  
6215  
6220  
6225  
6230  
6235  
6240  
6245  
6250  
6255  
6260  
6265  
6270  
6275  
6280  
6285  
6290  
6295  
6300  
6305  
6310  
6315  
6320  
6325  
6330  
6335  
6340  
6345  
6350  
6355  
6360  
6365  
6370  
6375  
6380  
6385  
6390  
6395  
6400  
6405  
6410  
6415  
6420  
6425  
6430  
6435  
6440  
6445  
6450  
6455  
6460  
6465  
6470  
6475  
6480  
6485  
6490  
6495  
6500  
6505  
6510  
6515  
6520  
6525  
6530  
6535  
6540  
6545  
6550  
6555  
6560  
6565  
6570  
6575  
6580  
6585  
6590  
6595  
6600  
6605  
6610  
6615  
6620  
6625  
6630  
6635  
6640  
6645  
6650  
6655  
6660  
6665  
6670  
6675  
6680  
6685  
6690  
6695  
6700  
6705  
6710  
6715  
6720  
6725  
6730  
6735  
6740  
6745  
6750  
6755  
6760  
6765  
6770  
6775  
6780  
6785  
6790  
6795  
6800  
6805  
6810  
6815  
6820  
6825  
6830  
6835  
6840  
6845  
6850  
6855  
6860  
6865  
6870  
6875  
6880  
6885  
6890  
6895  
6900  
6905  
6910  
6915  
6920  
6925  
6930  
6935  
6940  
6945  
6950  
6955  
6960  
6965  
6970  
6975  
6980  
6985  
6990  
6995  
7000  
7005  
7010  
7015  
7020  
7025  
7030  
7035  
7040  
7045  
7050  
7055  
7060  
7065  
7070  
7075  
7080  
7085  
7090  
7095  
7100  
7105  
7110  
7115  
7120  
7125  
7130  
7135  
7140  
7145  
7150  
7155  
7160  
7165  
7170  
7175  
7180  
7185  
7190  
7195  
7200  
7205  
7210  
7215  
7220  
7225  
7230  
7235  
7240  
7245  
7250  
7255  
7260  
7265  
7270  
7275  
7280  
7285  
7290  
7295  
7300  
7305  
7310  
7315  
7320  
7325  
7330  
7335  
7340  
7345  
7350  
7355  
7360  
7365  
7370  
7375  
7380  
7385  
7390  
7395  
7400  
7405  
7410  
7415  
7420  
7425  
7430  
7435  
7440  
7445  
7450  
7455  
7460  
7465  
7470  
7475  
7480  
7485  
7490  
7495  
7500  
7505  
7510  
7515  
7520  
7525  
7530  
7535  
7540  
7545  
7550  
7555  
7560  
7565  
7570  
7575  
7580  
7585  
7590  
7595  
7600  
7605  
7610  
7615  
7620  
7625  
7630  
7635  
7640  
7645  
7650  
7655  
7660  
7665  
7670  
7675  
7680  
7685  
7690  
7695  
7700  
7705  
7710  
7715  
7720  
7725  
7730  
7735  
7740  
7745  
7750  
7755  
7760  
7765  
7770  
7775  
7780  
7785  
7790  
7795  
7800  
7805  
7810  
7815  
7820  
7825  
7830  
7835  
7840  
7845  
7850  
7855  
7860  
7865  
7870  
7875  
7880  
7885  
7890  
7895  
7900  
7905  
7910  
7915  
7920  
7925  
7930  
7935  
7940  
7945  
7950  
7955  
7960  
7965  
7970  
7975  
7980  
7985  
7990  
7995  
8000  
8005  
8010  
8015  
8020  
8025  
8030  
8035  
8040  
8045  
8050  
8055  
8060  
8065  
8070  
8075  
8080  
8085  
8090  
8095  
8100  
8105  
8110  
8115  
8120  
8125  
8130  
8135  
8140  
8145  
8150  
8155  
8160  
8165  
8170  
8175  
8180  
8185  
8190  
8195  
8200  
8205  
8210  
8215  
8220  
8225  
8230  
8235  
8240  
8245  
8250  
8255  
8260  
8265  
8270  
8275  
8280  
8285  
8290  
8295  
8300  
8305  
8310  
8315  
8320  
8325  
8330  
8335  
8340  
8345  
8350  
8355  
8360  
8365  
8370  
8375  
8380  
8385  
8390  
8395  
8400  
8405  
8410  
8415  
8420  
8425  
8430  
8435  
8440  
8445  
8450  
8455  
8460  
8465  
8470  
8475  
8480  
8485  
8490  
8495  
8500  
8505  
8510  
8515  
8520  
8525  
8530  
8535  
8540  
8545  
8550  
8555  
8560  
8565  
8570  
8575  
8580  
8585  
8590  
8595  
8600  
8605  
8610  
8615  
8620  
8625  
8630  
8635  
8640  
8645  
8650  
8655  
8660  
8665  
8670  
8675  
8680  
8685  
8690  
8695  
8700  
8705  
8710  
8715  
8720  
8725  
8730  
8735  
8740  
8745  
8750  
8755  
8760  
8765  
8770  
8775  
8780  
8785  
8790  
8795  
8800  
8805  
8810  
8815  
8820  
8825  
8830  
8835  
8840  
8845  
8850  
8855  
8860  
8865  
8870  
8875  
8880  
8885  
8890  
8895  
8900  
8905  
8910  
8915  
8920  
8925  
8930  
8935  
8940  
8945  
8950  
8955  
8960  
8965  
8970  
8975  
8980  
8985  
8990  
8995  
9000  
9005  
9010  
9015  
9020  
9025  
9030  
9035  
9040  
9045  
9050  
9055  
9060  
9065  
9070  
9075  
9080  
9085  
9090  
9095  
9100  
9105  
9110  
9115  
9120  
9125  
9130  
9135  
9140  
9145  
9150  
9155  
9160  
9165  
9170  
9175  
9180  
9185  
9190  
9195  
9200  
9205  
9210  
9215  
9220  
9225  
9230  
9235  
9240  
9245  
9250  
9255  
9260  
9265  
9270  
9275  
9280  
9285  
9290  
9295  
9300  
9305  
9310  
9315  
9320  
9325  
9330  
9335  
9340  
9345  
9350  
9355  
9360  
93

along the outside of the racquet until reaching the next string hole, in this manner avoiding direct contact with the graphite frame.

Over the years, newer, stiffer frame materials, together with advances in molding techniques, have allowed composite sports racquets to become increasingly light. Today's graphite tubular frames as molded are very strong and very stiff, even with very thin wall thicknesses. However, when racquet string holes are subsequently drilled in the racquet, carbon fibers are broken and the frame is weakened locally. This problem is exacerbated by the fact that the string holes must have a diameter large enough not just for a string, but for a plastic grommet peg. As frame walls have become increasingly thin, the process of drilling the string holes can weaken the frame significantly, to the point where the frame is unable to support the high forces of the tensioned strings, resulting in strings pulling through the walls of the frame tube.

Commonly owned U.S. patent No. 6,071,203 discloses a two-piece sports racquet comprising a tubular upper frame half and a tubular lower frame half. The two racquet halves are molded separately from one another, and then bonded together, along opposed walls, using epoxy. The opposed walls of the two racquet halves are molded with half cylindrical channels which, when the two halves are joined, form the string holes of the frame, thereby eliminating the need to drill string holes and thereby weakening the frame. Also, when the two racquet halves are joined, the opposed walls become an internal wall in the frame which is oriented

parallel to the direction of the string force on the frame, thereby further helping to prevent string pull-through.

5

While the invention disclosed in U.S. patent No. 6,071,203 provides a beneficial improvement in sports racquets, it would be desirable to provide a two piece-racquet having the same structural advantages, but without the need to bond two racquet halves together following molding.

#### BRIEF SUMMARY OF THE INVENTION

In a method for making a composite sports racquet frame according to the invention, a mold is provided having first and second mold plates which, when joined, define a mold cavity in the shape of a sports racquet. A first tube of a material suitable for forming a racquet frame, such as a fiber-reinforced resin, is placed in the first mold plate. A second tube of such material is placed in the second mold plate. A plurality of pin plates, each having a plurality of pins which are preferably at least substantially parallel to one another, are secured to the first mold plate so that the pins lie on top of the first tube.

20

After coupling a compressed air source to each of the tubes, the mold plates are secured to one another so that the first and second tubes contact one another at least in the regions to either side of the pins. The mold is then heated, while at the same time pressurizing the tubes, to form a racquet frame in which the tubes are joined to one another at least in the regions adjacent to the pins.

Preferably, the tubes are made of a composite material having a component, such as epoxy resin or thermoplastic, which, when subjected to the heat and pressure of the mold, will flow. In this manner, during molding the contacting portions of the two tubes will fuse together to form a common, integral, internal wall.

5

After the molded frame has been removed from the mold plates, the pins are pulled out of the frame, the pins thereby forming string holes in the frame.

Preferably, the pin plates forming the string holes in the head portion of the racquet are disposed on the outside surface of the head portion, so that the pins project inwardly. The base of the pins, i.e., where the pin project from the pin plates, are contoured so that the string hole openings formed by the pins along the outside surface of the racquet are rounded, thereby reducing the chance of string breakage.

Preferably, the tubes, when in the mold, alternately contact one another and a pin along the entire head portion of the frame. Preferably, the ends of the tube which will form the racquet handle portion are kept separated from one another during molding, by using a removable mold plate.

20

Also, preferably, the inner surface of the pin plates, from which said pins project, forms part of the mold cavity, e.g., to define a string groove extending along the outside of the head portion of the frame between string holes.

For a better understanding of the invention, reference is made to the following detailed description of the preferred embodiments of the invention, taken in conjunction with the drawings accompanying the application.

5

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

Fig. 1 is a plan view of the bottom half of a mold for making a sports racquet according to the invention;

Fig. 2 is a plan view of the upper half of such mold;

Fig. 3 is a plan view of the bottom half of the mold containing a prepreg tube, various removable pin plates, and a handle plate secured in place;

Figs. 4-9 are plan views illustrating the various pin plates used in the mold half of Fig. 3;

Fig. 10 is an enlarged, perspective view of a portion of the mold half of Fig. 3 along with several pin plates;

Fig. 11 is a plan view of a racquet frame molded with the mold halves and plates shown in Figs. 1-9;

Figs. 12 and 13 are cross sectional views of the frame of Fig. 10, taken through lines 12-12 and 13-13, respectively;

Fig. 14 is a perspective view of the end of the handle portion of the frame shown in Fig. 11;

20

Fig. 15 is a front view of an alternative embodiment of pin plate, in which the pins lie in two different planes;

Fig. 16 is a plan view of a portion of the lower mold plate, prepreg tube, and pin plates according to another embodiment of the invention;

5

Fig. 17 is a plan view of a portion of the lower mold plate, prepreg tube, and pin plates according to still another embodiment of the invention;

Fig. 18 is a plan view of a portion of the lower mold plate, prepreg tube, and grommet strip according to still another embodiment of the invention;

Fig. 19 is a plan view of a portion of the lower mold plate, prepreg tube, and pins according to another embodiment of the invention;

Fig. 20 is a plan view of a portion of the lower mold plate, prepreg tube, and pin plates according to another embodiment of the invention;

Fig. 21 is a plan view of a portion of the lower mold plate, prepreg tube, and sacrificial pins and spines according to another embodiment of the invention;

20

Fig. 22 is a plan view of a portion of the lower mold plate, prepreg tube, and pins according to yet another embodiment of the invention; and

Fig. 23 is a view corresponding to Figure 13 another embodiment of a tennis racquet frame.

#### DETAILED DESCRIPTION OF THE INVENTION

5 Fig. 1 shows a mold plate 10 which forms the bottom half of a mold for making a tennis racquet. Fig. 2 shows a second mold plate 12 which forms the upper half of the mold.

The bottom mold plate 10 and upper mold plate 12 have generally flat upper surfaces 14, 16, respectively. The bottom mold plate 10 has a plurality of dowels 18 which are received in corresponding holes 20 in the upper mold plate 12 when the molds are brought together.

The bottom mold plate 10 includes a mold cavity 11 in the shape of a tennis racquet half (i.e., if the racquet were cut in half through a central plane parallel to the string bed), including a generally oval head portion 22, an arcuate throat bridge portion 24, converging shaft portions 26, and handle portions 28. As shown, the handle portions 28 of the mold are separated from one another by a wall portion 30. An enlarged cutout 32 is provided at the ends of the handle portions 28.

20 In addition to the mold portions 22, 24, 26, and 28, a sunken ledge 34, which lies below the plane of the surface 14 but which is not as deep as the mold portions 22, 24, 26, and 28, extends around the outside of the mold portion 22 and part of the mold portions 26. A second sunken ledge 36 adjoins the throat bridge portion 24.

5

A plurality of dowels 38 (only some of which are numbered on Fig. 1) extend upwardly from the bottom surface of the sunken ledges 34, 36. In addition, a plurality of latches 40 are pivotably secured to the plate surface 14 and spaced about the head and throat portions 22, 24 of the mold cavity 11 directly adjacent the sunken ledges 34, 36. In the rotational position shown, the latches 40 expose the two ledges 34, 36.

The head and throat mold portions 22, 24 surround a generally oval portion 14a of the upper surface 14 of the bottom mold plate 10. A plurality of thin grooves 23, described below in greater detail, extend from the mold portions 22, 24 inwardly toward the center portion 14a.

As also shown in Fig. 1, a pair of sunken ledges 39 are formed in the surface 14 on either side of the handle portions 28 of the mold. Latches 41 are pivotably mounted to the side of one of the ledges 39. The upper surface of the wall portion 30 is preferably co-planar with the ledges 39.

20

Referring to Fig. 2, the upper mold plate 12 includes a mold cavity 13 in the shape of a tennis racquet half and preferably is the mirror image of the mold cavity 11 in the bottom mold plate 10. Thus, the mold cavity 13 in the upper mold plate also includes a generally oval head portion 42, an arcuate throat bridge 44, converging shaft portions 46, and handle portions 48. As shown, the handle portions 48 of the mold are separated from one another by a wall portion 50. An enlarged cutout 52 is provided at the ends of the handle portions 28. The mold portions 42, 44,

5

46, 48 in the upper mold plate 12 are located such that, when the dowels 18 of the bottom mold plate 10 are inserted in the holes 20 of the upper mold plate 12, the mold portions 42, 44, 46, 48 will lie opposite to the corresponding mold portions 22, 24, 26, 28 in the bottom mold plate 10, thereby forming a closed mold cavity 11, 13 in the shape of a tennis racquet..

The upper mold plate 12 includes a sunken ledge 54, which lies below the plane of the surface 16 but which is not as deep as the mold portions 42, 44, 46, and 48. The ledge 54 extends around the outside of the mold portion 42 and part of the mold portion 46. A second sunken ledge 56 adjoins the throat bridge mold portion 44. The ledges 54 and 56 formed in the upper mold plate 12 are mirror images of the ledges 34, 36 of the bottom mold plate 10 and are positioned to lie opposite to the ledges 34, 36 when the dowels 18 of the bottom mold plate 10 are inserted into the holes 20 of the upper mold plate 12. A pair of sunken ledges 39a are formed in the upper surface 16 so as to be opposite to the ledges 39 in the bottom mold plate 10 when the plates are joined.

20

Finally, a plurality of holes 53 are formed in the upper surface 16 of mold plate 12 and located so that, when the two mold plates 10, 12 are joined, the latches 40, 41 of the bottom mold plate 10 are received in the holes 53 of the upper mold plate 12, thus allowing the plate surfaces 14, 16 of the respective mold plates to abut against one another.

5

Fig. 3 shows the bottom mold plate 10 after a prepreg tube 60 has been laid in the mold portions 22, 26, 28. The prepreg tube 60 may be prepared in a conventional fashion, in which strips of uncured, fiber-reinforced epoxy resin are wrapped on a mandrel to form a flexible tube. In accordance with conventional practice, an additional section 61 of tubing is laid in the throat mold section 24 and is joined to the opposite sides of the tube 60 (e.g., by wrapping additional prepreg strips around the joints) to form the throat piece.

After the tube 60 and throat section 61 have been laid in the mold portions 22, 24, 26, 28, a plurality of pin plates 70a, 70b, 72a, 72b, 74a, 74b, 76a, 76b, and 78 are positioned in the sunken ledge 34. Another pin plate 80 is placed in the ledge 36. Each pin plate includes a plurality of holes 84 which fit over the dowels 38 of the bottom mold plate 10, thereby fixing the position each pin plate.

20

Each pin plate also includes a plurality of pins 71, 73, 75, 77, 79, and 81. The pins of each pin plate extend parallel to one another. As shown in Fig. 3, when the pin plates 70a-b, 72a-b, 74a-b, 76a-b, 78 and 80 are positioned in the ledges 34, 36, the pins 71, 73, 75, 77, 79, and 81 cross the open, upper end of the mold portions 22 and 24 on top of the prepreg tube 60 and throat section 61, respectively. As shown more clearly in Fig. 10, which shows pin plates 74b, 76b, and 78, the ends of the pins 75, 77, 79 are received in the grooves 23 formed in the upper surface 14a of the bottom mold plate 10. After the plates 70a-b, 72a-b, 74a-b, 76a-b, 78

and 80 have been positioned in the ledges 34, 36, the latches 40 are rotated to secure the plates against movement.

5

The pin plates 70a-b, 72a-b, 74a-b, 76a-b, 78 and 80 are shown in greater detail in Figs. 4-10. Each plate has a body portion 90 and a plurality of parallel pins 71, 73, 75, 77, 79, 81, thus resembling a comb. The inner face 91 of each plate forms part of the mold surface for the racquet, and thus has the exact shape desired for the racquet. For example, the inner faces 91 of the various plates may extend into the mold space formed by the head portion 22 so as to form a stringing groove along the outside surface of the finished racquet. The opposite ends 94 of each pin plate are designed to abut either the end of an adjacent plate or, in the case of plates 70a-b and 80, an end wall of the ledge 34, 36.

As shown in Fig. 10, the base 75a, 77a, and 79a of each pin 75, 77, 79 (as well as the remaining pins), i.e., where each pin joins the pin plate, is rounded. As described further below, when the racquet frame is molded, the pins form string holes in the frame. By rounding the base of the pins, the string holes openings along the outside of the frame will similarly be rounded.

20

Referring again to Fig. 3, a handle plate 96 is seated in the sunken ledges 39, over the handle portions of the prepreg tube 60, and locked in place with the latches 41. Finally, a pair of air nozzles 98 are inserted into the open ends of the tube 60. As shown, the cutout space 32 provides room to maneuver the nozzles 98 into place.

5

To form the racquet frame, the bottom mold plate 10 is prepared as described above, i.e., a prepreg tube 60 is placed in the mold cavity 11, the pin plates and handle plate are positioned as shown in Fig. 3, the latches 40, 41 are rotated 90 degrees to secure the pin plates and handle plate in place, and air nozzles 98 are inserted in the ends of the tube 60. A second prepreg tube and throat section, similar to prepreg tube 60 and throat section 61, are disposed in the upper mold plate 12, and air nozzles similar to air nozzles 98 are inserted in the open ends of the second tube. The two mold plates 10, 12 are then brought together so that the dowels 18 of the bottom mold plate 10 are received in the holes 20 of the upper mold plate 12. As the mold plates 10, 12 come together, the portions of the pin plates 70a-b, 72a-b, 74a-b, 76a-b, 78 and 80 and handle plate 96 which project above the plane of the surface 14 will be received in the respective sunken ledges 54, 56 and 39a of the upper mold plate 12, so that the surfaces 14, 16 lie flush against one another. The two mold plates 10, 12 are then clamped together in a known manner.

20

Once the mold is closed, it is heated to a suitable temperature to begin to cure the epoxy resin. At the same time, pressurized air is provided to the air nozzles to cause the two prepreg tubes to assume the shape of the mold. The pressurized air also forces the upper prepreg tube and throat section into contact with the lower prepreg tube 60 and throat section 61, except where the two tubes are separated by the pins 71. Due to the heat and pressure present in the mold, as the two tubes are curing,

the resin of the tubes will tend to migrate, so as to form a unitary structure.

After the epoxy has been sufficiently cured, the mold is opened, the latches 41 are pivoted 90 degrees to their open position, and the racquet frame, along with the pin plates 70a-b, 72a-b, 74a-b, 76a-b, 78 and 80, and handle plate 96 are removed.

Once the racquet frame has been removed from the mold, the pin plates 70a-b, 72a-b, 74a-b, 76a-b, 78 and 80 can be withdrawn, one-by-one, from the frame, thereby withdrawing the pins 71. Also, the handle plate 96 can slide between the handle portions 100a-b and 100c-d so as to be removed.

The molded frame is shown in Figs. 11-14. As a result of this process, in the head portion 110, throat bridge 112, and shaft portions 114 of the frame, the upper and lower tubes are fused to one another, due to the curing process, to form a unitary frame member, except where the pins 71 have kept the tubes separated. Fig. 12 shows a cross section of the head portion 110 in which the lower tube 60 has become integral with the upper tube 60a (the broken line merely indicating the pre-molding boundary between the two tubes). As shown, a string groove 119 has been molded along the outside surface of the frame by the surfaces 91 of the pin plates.

Fig. 13 is a cross section of the head portion 110 showing a string hole 120 which has been formed by one of the pins 75. As discussed above, by rounding the base of the pins, the opening 121 of the string hold

120 along the outside of the frame, where strings enter and leave the frame, will be rounded, thereby reducing the chance of damaging the string and reducing the need for grommet pegs.

5

When the racquet is strung, the strings will be disposed in the string groove 119 along the outside of the frame, and extend through the string holes 120. The tension of the strings tends to pull the outwardly facing wall 126 of the frame inwardly. As shown in Figs. 12-13, the wall 124 formed when the two pre-preg tubes are molded extends directly below the string groove 119, and is oriented parallel to the direction of string force. Thus, the wall 124 effectively opposes the tendency of string pull-through.

10  
Centene  
- 025  
602

In accordance with the present invention, it is not necessary to attach the two tubes to one another after molding. It is also not necessary to drill string holes, after the racquet has been molded, as in the case of conventional composite racquets. Finally, particularly where the hole openings 121 are rounded, as in Fig. 13, it is not necessary to employ grommet pegs to protect the strings, although grommet pegs may be used if desired.

20

As shown in Figs. 11 and 14, the four ends 100a-d of the tubes, which form the handle portion 116 of the racquet frame, are separated from one another. A handle pallet (not shown) may be secured to the handle portion 116 in a known fashion, and a grip may be wound on to the handle pallet.

Other Alternative Embodiments

Fig. 15 shows an alternative embodiment of a pin plate 200, in which the pins are parallel to one another but not in the same plane. In the example shown in Fig. 15, the pins 202, 204 lie alternately above and below the plane "P" of the string bed. Pin plates such as pin plate 200 can be used to make a racquet with "splayed" stringing, such as described in U.S. SIR H1,710.

Alternatively, adjacent pins could be angled up or down, planar and convergent, or skewed (meaning neither parallel nor convergent). In such cases, the invention should incorporate one of the following modifications.

- (a) Each pin plate has only a single pin. This offers the flexibility of orienting each pin at the most desired angle and location. In the case of convergent pins, as shown in Fig. 16, the pin plates 206, 207, 208 can slide in a common plane, but in different directions d1, d2, and d3, when being removed from the racquet frame after molding. In the case of skewed pins, as shown in Fig. 17, each pin plate 210, 211, 212 has its own sliding plane specifically oriented to have the desired channel position and sliding direction d4, d5, d6.
- (b) Each pin plate has at least two pins, but they have sufficient resiliency to bend when being pulled out of the frame; or
- (c) Each pin plate has a system that allows the pins to be withdrawn along their own axis.

Another modification which forms part of this invention is the use of fusible, or sacrificial, core material to form either pin plates or individual pins. The use of fusible cores in the formation of tennis racquets is described in U.S. patent No. 4,891,175. Such cores are used to help mold the frame, but can be removed after the frame material has hardened, e.g., by melting or washing away. In the present invention, similar materials could be used to form the pins used to mold in string holes, which pins are then removed after the frame has been cured.

Another alternative embodiment according to the invention utilizes hollow plastic grommet pegs as the pins (as used herein, the term "pins" includes plastic grommet pegs as well the aforescribed fusible core pins). In such an arrangement, illustrated in Figure 18, a grommet strip 220, containing a plurality of hollow grommet pegs 222, is positioned in the mold in a manner similar to the pin plates, i.e., such that the grommet pegs 222 extend across the top surface of one of the prepreg tubes 60. The grommet pegs are positioned in the desired locations of the string holes. The top mold plate is then positioned so that the upper prepreg tube lies on top of the grommet pegs 222. When molded, the grommet strip 220 lies in the stringing groove. Because the grommet pegs 222 are not removed after molding, but are intended to become a permanent part of the frame, such grommet pegs 222 can be oriented at any desirable angle. As shown, the grommet pegs are oriented to be perpendicular to the frame's outer surface at each location.

Fig. 19 shows another embodiment in which pin plates are not used. Rather, the mold plates, e.g., lower mold plate 230, are formed to secure opposite ends of individual pins 232. For example, grooves 234a, 234b similar to grooves 23, could be formed both on the inside surface 236 and the outside surface 238 of the mold plate, with complementary grooves formed in the upper mold plate. The grooves 234a, 234b position the individual pins 232 at the desired locations. In this embodiment, the pins 232 can be oriented at any desired angle. After the frame has been molded and removed from the mold plates, the pins are removed, e.g., with a hammer or press. Preferably, the base 233 of one end of each pin 232 is radiused, so that the inlet to the string hole thus formed will be rounded. Where the base 233 is enlarged in cross section as shown, the pin 232 is removed in a direction towards its base end.

As a string enters or leaves a string hole on the outside surface of the frame, it bends at an angle of 90 degrees in order to extend along the outside surface of the frame to the next string hole. Thus, in the above embodiments, it is preferable to radius the inlet of the string hole lying on the outside of the frame so that the string does not encounter a sharp edge of the frame tube when bending. It is also preferable to mold a radius at the string hole opening on the inside surface of the frame as well.

One way to do this, illustrated in Fig. 20, is to separate the pins into two sections 240a, 240b which meet somewhere in the middle of the molded frame cross-section. Each section 240a, 240b is secured to its

own pin plate 242a, 242b. In this manner, the base 243a, 243b of each pin section 240a, 240b is rounded to produce a radius at both ends of the string hole thus formed.

As an alternative, where a fusible core material is used to form the pins, the opposite ends of such pins can be round to produce the desired radius. For example, a lattice work design of pins 250 connected by two spines 252, 254 on the outside surface and inside surface, respectively, could be used, as shown in Fig. 21. The opposite ends of the pins 250, i.e., where the pins 250 are connected to the spines 252, 254 could be radiused so that the openings to the resulting string holes are rounded. Because the material is melted or washed away after the frame is molded, such pins 250 can be oriented at any desired angle. Moreover, the fact that both ends are curved does not prevent such pins 250 from being removed, because the material merely melts or otherwise disintegrates.

20

As another alternative, individual pins can be used to form the string holes, similar to the embodiment shown and described in connection with Figure 22. However, instead of having pins 232 in which the outer end is radiused but the inner end is straight, as in Fig. 17, which will radius only the outer end of the string hole, both ends of the pins 260 are radiused. The mold plates are provided with complementary grooves 261 to receive the enlarged ends of the pins 260. At least one of the ends is formed so that the enlarged portion is removable. This may be accomplished, e.g., by providing a removable cone 265 on one or both of the ends. The cones

would form the radii during molding, but at least one of the cones would be removable after molding to allow the pin to be pulled out.

5

Fig. 23 shows a cross section corresponding to Figure 13 of another racquet frame 300. A plurality of hollow, tubular metal grommet pegs 302 (one of which is shown in Fig. 23) extend through the frame 300 from the outer surface 304 of the frame to the inner surface 306 of the frame. As shown, the opposite ends 310, 312 of each grommet peg 304 flare outwardly (i.e, in a flared bell, or trumpet, shape), so that the opposite ends of the interior walls 314 of each grommet peg 304 are rounded, as shown. In this manner, as the string enters and extends through the grommet peg 304, it will not encounter any sharp edges.

10  
15  
20

As shown in Fig. 23, the grommet pegs 304 are located between the upper tube 316 and the lower tube 318 of the two piece racquet. To form the racquet, after the prepreg tube for forming the lower tube 316 has been placed in the lower mold half, the metal grommet pegs 302 are positioned over the upper, exposed surface of the prepreg tube at the desired locations. The upper prepreg tube, for forming the upper tube 316, and its associated mold are then positioned over the lower mold, lower prepreg tube, and grommet pegs 302, and the frame is formed as in the other embodiments. Once the racquet halves are joined and molded, the flared shape of the opposite ends of the metal grommet pegs act to secure the grommet pegs 302 and prevent any axial motion. Metal grommet pegs have the advantage that they can be made relatively thin-walled and light,

but such pegs will have a long life. If desired, however, grommet pegs similar to the grommet peg shown in Fig. 23, i.e., having flared opposite ends and which are permanently retained between the frame halves, may be made of other materials such as plastic.

5

The foregoing represent preferred embodiments of the invention. Variations and modifications will be apparent to persons skilled in the art, without departing from the inventive concepts disclosed herein. For example, while the process has been described as using tubes of uncured epoxy, other materials, including thermoplastic tubes, braided sleeves, or the like, may be employed. Also, the material used to make the upper racquet half need not be the same as the material used to make the lower racquet half, and the two racquet halves need not be symmetrical. Also, while the exemplary racquet frame includes a throat bridge, the process may be employed to form a frame that does not include a throat bridge. Finally, while the pins 71 of each pin plate are preferably parallel to one another to facilitate withdrawing the pins from the molded frame, such pins 71 can be non-parallel to one another, provided that they have sufficient resiliency to bend when being pulled out of the frame. As used herein, the term "substantially parallel" refers to pins which are sufficiently parallel to one another to allow the pins to be withdrawn from the frame without damaging the frame. All such modifications and variations are intended to be within the scope of the invention, as defined in the following claims.

20